



Memorandum

To: File Ref. No.: 11102641.07

From: David Steele/Arlie Weigley Date: August 3, 2016

cc: Colleen Costello

Subject: Marcus Hook Industrial Complex - Tidal Study

1. Purpose

Marcus Hook Refinery Operations, a series of Evergreen Resources Group, LLC (Evergreen) is completing activities in accordance with the Pennsylvania Department of Environmental Protection (PADEP's) Act 2 Program, the PADEP Tank Program, the Delaware Department of Natural Resource and Environmental Control (DNREC) Tank Program and the United States Environmental Protection Agency (USEPA) Resource, Conservation and Recovery Act (RCRA) program at the Marcus Hook Industrial Complex (Site). In support of these investigations, GHD completed a tidal study of the Delaware River and shallow groundwater along the Delaware River interface at the Site.

2. Study Design

Monitoring wells were evaluated prior to selecting the locations used to complete this study to ensure that Non-Aqueous Phase Liquid (NAPL) was not present, the monitoring well was functional, and the groundwater table was within the screened interval. No recovery wells were used as part of this study. Transducers were deployed in fifteen monitoring well locations spaced evenly along the river front. Thirteen of the monitoring wells were located within 100 feet of the Delaware River, while two of the monitoring wells (MW26 and MW533U) were set back approximately 300 feet from the riverfront to assess the difference in tidal impact with distance from the river. In addition, a 1.5 inch PVC stilling well was set up at Dock 3 to gauge the water level in the river for comparison. Transducers were deployed at each location from September 30, 2015 to November 5, 2015. Synchronized water level measurements were collected every 15 minutes at each transducer location. Attachment A includes a figure showing the locations used in the Tidal Study.

3. Methods

Factory calibrated level TROLL 500 model transducers were selected to conduct this study. Since this model is vented to the atmosphere, no correction for barometric pressure was required. Transducers were configured to record the depth of water above the transducer in feet. The depth of the transducer and the depth to water below top of riser was recorded during installation and one week into the testing for comparison to the real-time transducer data to ensure the transducers were reading accurately in the field.



The transducers were secured in the monitoring wells by a cable and bracket to prevent the transducer depth from changing during the study period. After the study was completed, the data was collected from the loggers using a handheld Rugged Reader PC. The data was converted from the .wsl transducer files to Excel files using the WinSitu software program to graph and interpret the results. GHD entered the top of riser elevation survey data and one depth to water measurement collected in the field so the WinSitu software could convert the data set to mean sea level. The converted data was then verified using a depth to water measurements collected at installation of the transducers on September 30, 2015, once a week later (October 6) and on the day of transducer retrieval (November 5).

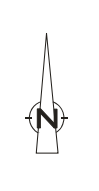
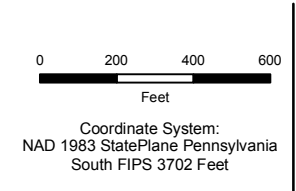
4. Results

All of the monitoring wells in the tidal study were tidally influenced. The locations situated closer to the riverfront show increased tidal influence and connectivity to the river, as shown in the graphed transducer data presented in Attachment B. The data from four monitoring well locations (MW-533U and MW-528U in AOI 7 and MW-26 and MW-28 in AOI 3) as well as river water elevations are shown in Attachment B. Data from October 1 to October 10, 2015 are displayed for clarity of presentation. As discussed above, MW-26 and MW-533U are both located approximately 300 feet inland and show a muted tidal response. The amplitude of the tidal impact is shown to decrease with distance from the riverfront. The average tidal amplitude is approximately six feet in the river and 1 to 2.7 feet at monitoring wells near the riverfront. Minimal tidal effects (stage change approximately 0.1 to 0.15 feet) are apparent at the locations 300 feet from the riverfront. Most of the wells displayed an identifiable sinusoidal pattern in their water levels (reflecting tidal influence) throughout the study, with the exception of MW-532U, MW-36, MW-214, MW-29 and MW-501. A limited response to changing river levels is expected to result from reduced hydraulic communication resulting from the presence of bulkheads or low permeability fill materials. An excel file with all of the data collected during the study is included as Attachment C (in electronic format).

Attachment A
Location of Wells in Tidal Study



Source: AOIs - Stantec; 2008 Evaluation of Sediment Remediation Goal, General Chemical / Honeywell, June 2012; 2010 Interim Remedial Measure Alternatives Assessment, Upstream Portion Sluiceway, March 12, 2012.□□□□
Aerial: S. Geological Survey April 02, 2016, 1 ft. Color Orthoimagery - USA County, PA



- Legend**
- Tidal Study Well Location
 - Well Location
 - 1951 Shoreline
 - Area Of Interest
 - Honeywell Sluiceway

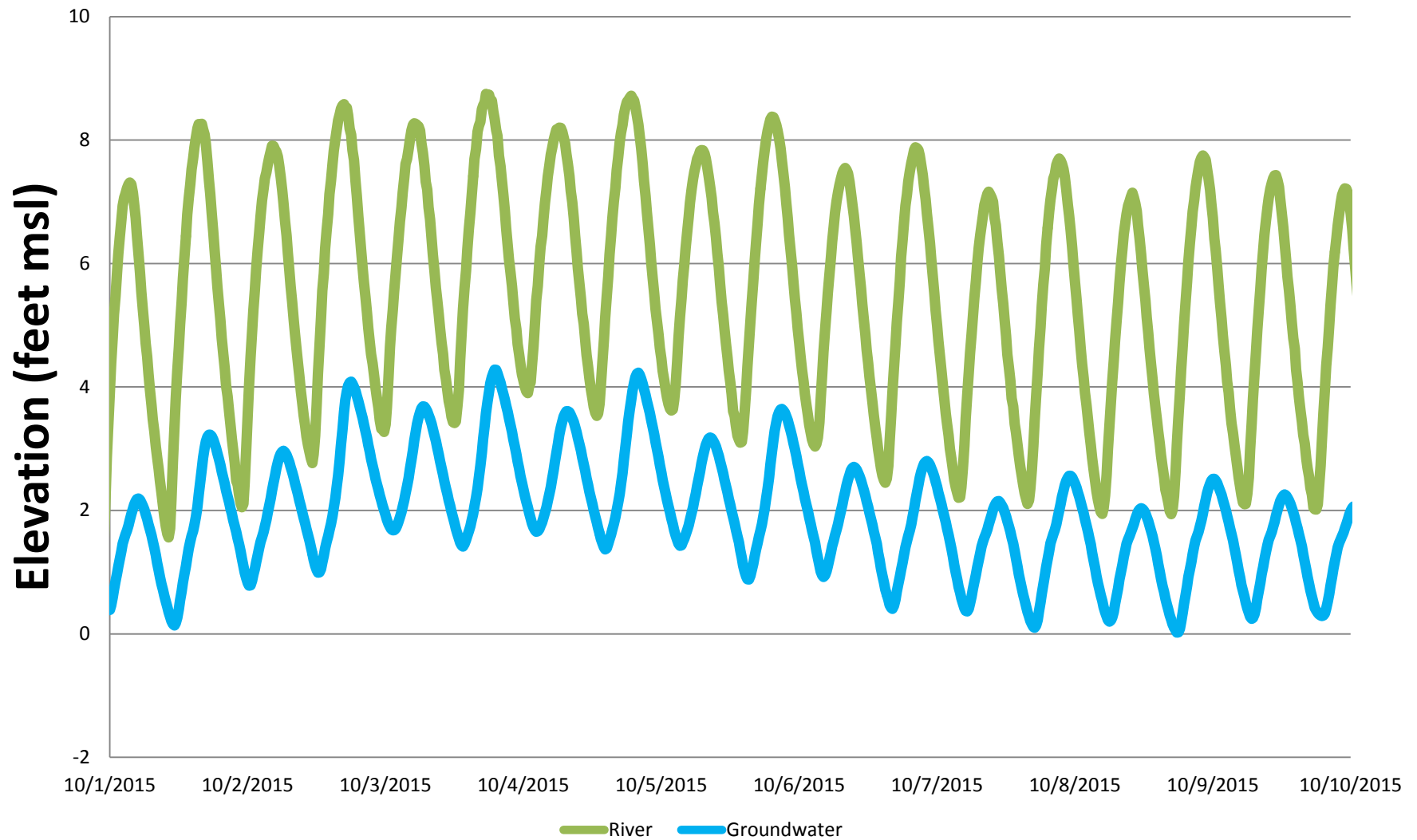


EVERGREEN RESOURCES MANAGEMENT
PHILADELPHIA REFINERY OPERATIONS
LOCATION OF WELLS IN TIDAL STUDY EVERGREEN RESOURCES
MANAGEMENT - MARCUS HOOK INDUSTRIAL COMPLEX
– SEPTEMBER-OCTOBER 2015

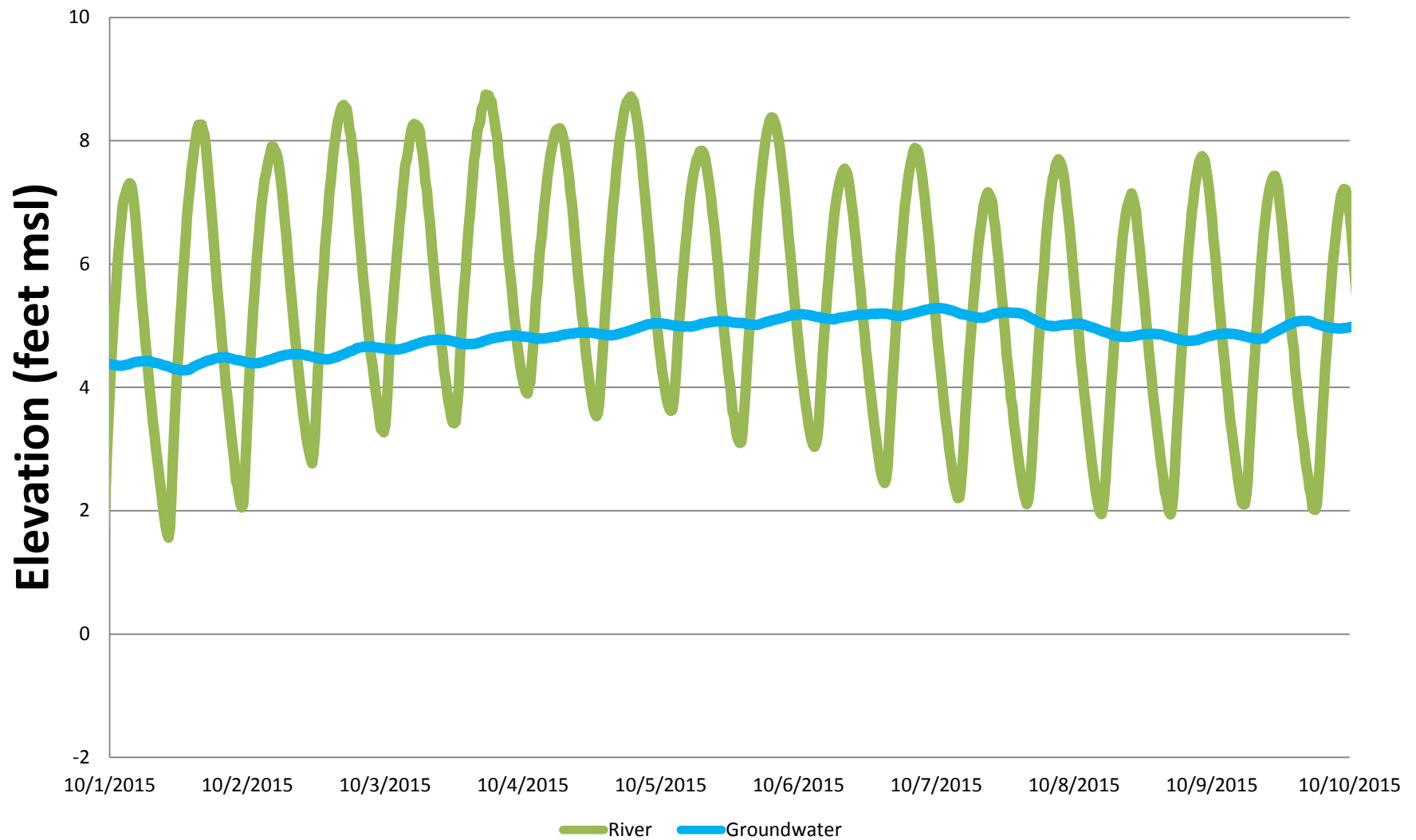
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Attachment B
Graphic Plots of Water Level Data

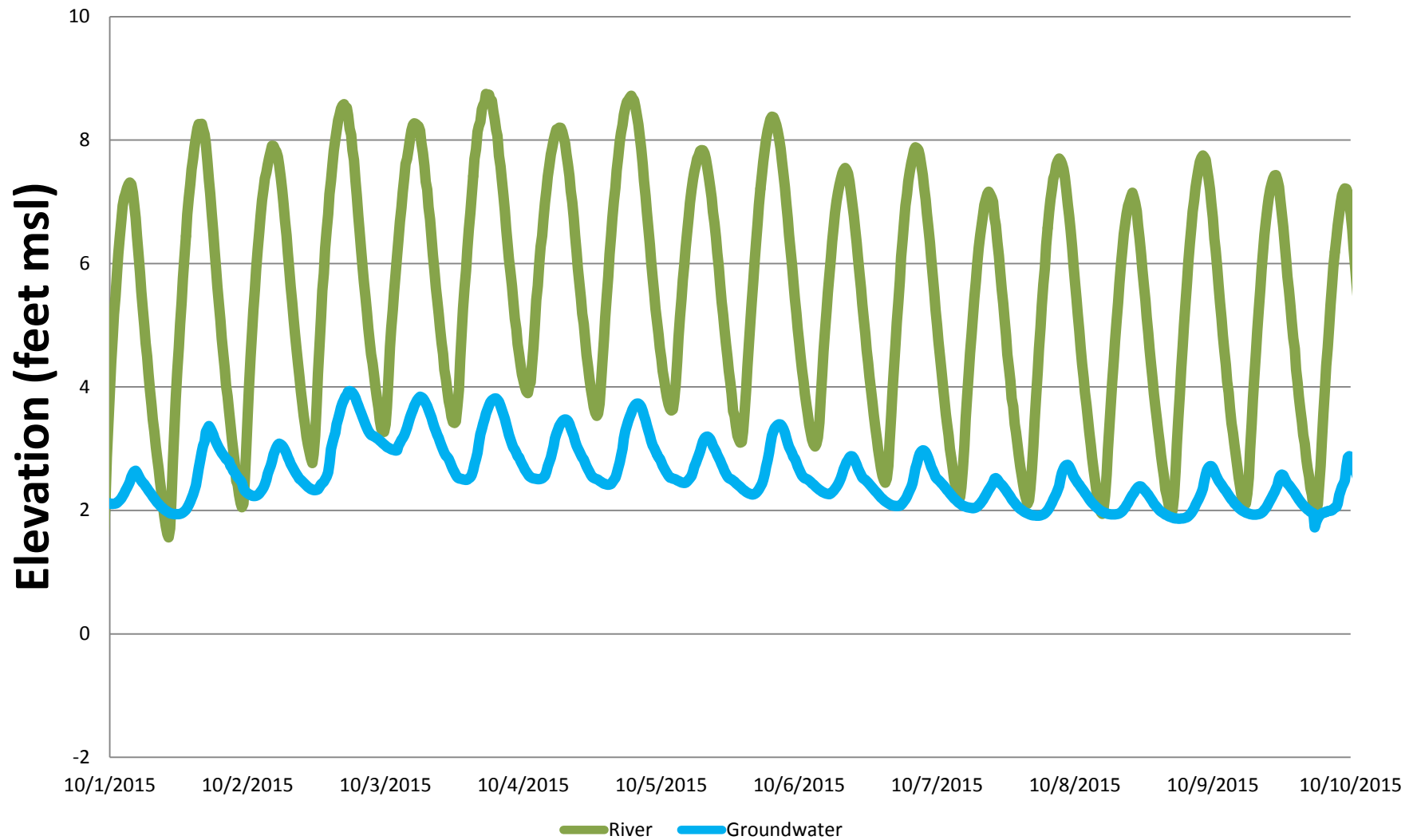
Groundwater Elevation in MW-528U Compared to River Elevation



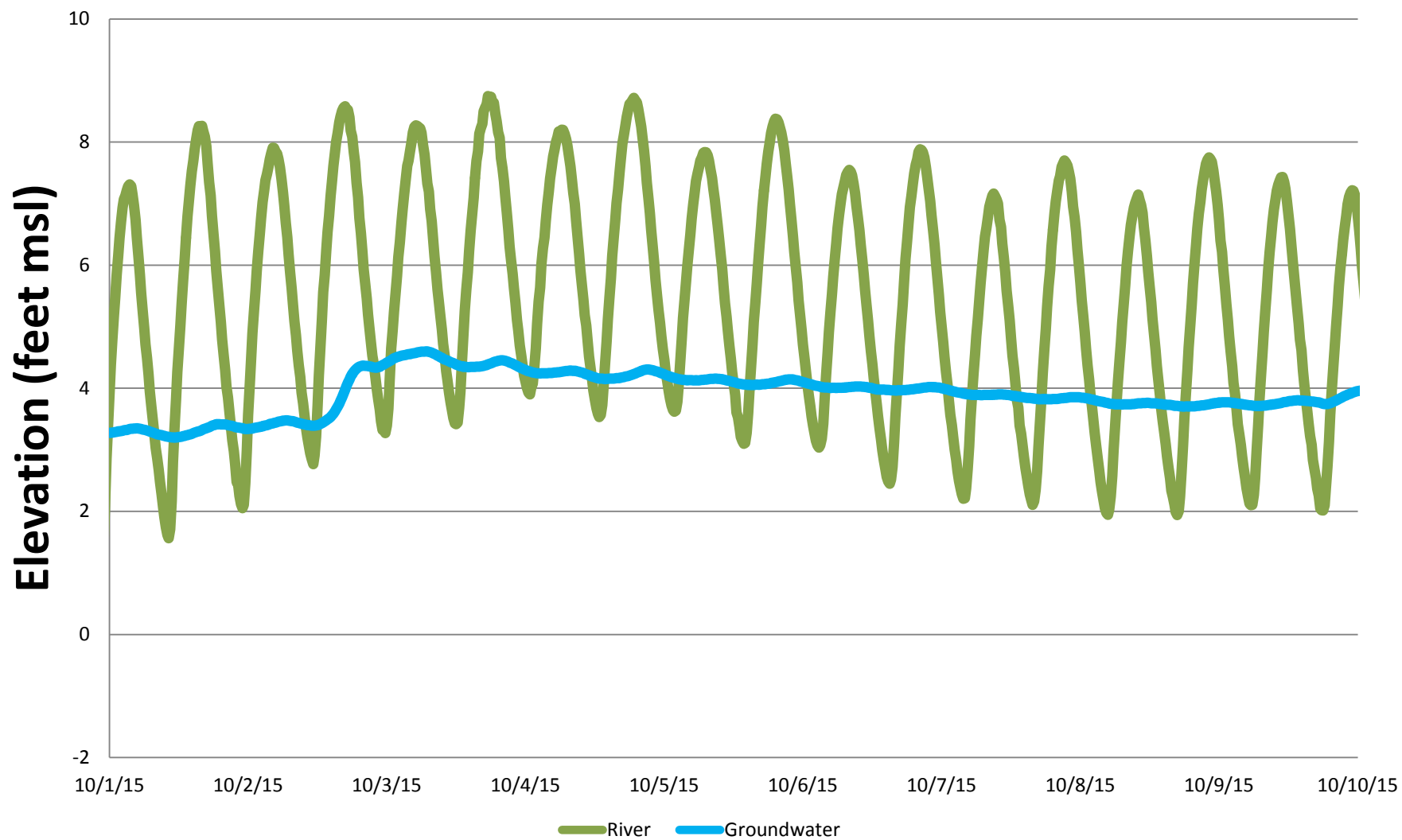
Groundwater Elevation in MW-533U Compared to River Elevation



Groundwater Elevation in MW-28 Compared to River Elevation



Groundwater Elevation in MW-26 Compared to River Elevation



Attachment C
Transducer Files
(Electronic Form – provided separately)